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PR powers air and space with hypersonic 'scramjet' program

by Michael Kelly, Propulsion Directorate

WRIGHT-PATTERSON AIR FORCE BASE, Ohio — Architect of American airpower, Gen. Hap Arnold said it plainly and passionately - "The first essential of air power is pre-eminence in research."

Scientists and engineers from the Propulsion Directorate here are achieving the pre-eminent research Arnold called for — research that is helping the Air Force dominate air and space - now and in the future. In fact, for more than 85 years, scientists, engineers, support personnel and contractors from the Air Force Research Laboratory's Propulsion Directorate have been answering Arnold's call for world-class research that puts capabilities into the hands of America's warfighters.

Supersonic combustion ramjet technology being developed under the Air Force Research Laboratory's HyTech program will enable missiles to fly at speeds up to Mach 8. Such conceptual missiles like the one pictured could fly hundreds of miles in minutes to defeat time-critical targets. (Graphic design by Mike Bruggeman)

Leading the way

Their goal is simple according to director, Col. Alan M. Janiszewski, "to lead the development of engines and power systems technologies for airplanes, missiles, launch vehicles and satellites."

One of the most promising technologies already being ground tested in the directorate is a supersonic combustion ramjet (scramjet) engine that uses conventional jet fuels to reach hypersonic speeds — speeds over Mach 5. This technology has the potential to power future hypersonic vehicles such as cruise missiles, space access vehicles and long range strike and reconnaissance aircraft at speeds up to eight times the speed of sound, said Robert Mercier, deputy for technology in the aerospace propulsion office. Today's aircraft and missiles fly in the Mach 0-3 range, he said.

Hypersonic technology

Dubbed "HyTech," for hypersonic technology, the program got its start in 1995, in the wake of the cancelled National Aero-Space Plane program, Mercier pointed out. That effort was aimed at developing a hydrogen-fueled, scramjet-powered, single-stage-to-orbit vehicle capable of aircraft-like horizontal takeoffs and landings.

The Air Force's version of the scramjet, he said, is designed to run on JP-7 fuel, which is more logistically supportable than hydrogen fueled engines. NASA continues to pursue the development of a hydrogen-fueled system with their "Hyper-X" program.

Anywhere, anytime

"By using hydrocarbon fuels, like JP-7, instead of hydrogen, we will be able to deploy these systems anywhere, anytime and any place," Mercier said.

Tests underway right now are designed to demonstrate the operability, performance and structural durability of the scramjet system.

With more than 2,000 hours of testing under their belts, the directorate's scientists and engineers, as well as contractors from Pratt and Whitney and United Technology Resource Center, have demonstrated the engine works, and are excited about extending this technology to systems that will give warfighters a distinct advantage over future enemies.

Faster cruise missiles

According to Mercier, "the most strenuous near-term application is for a fast reaction, long-range air-to-ground missile

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cruising at Mach 6 plus — more than 4,500 mph.

"The missile would be launched from bombers or fighters, then brought up to speeds of about Mach 4 using a rocket booster. The scramjet would then kick in, allowing the weapon to fly hundreds of nautical miles in minutes to reach time-critical targets," he explained.

"This type of weapon would fly seven times faster than a conventional cruise weapon and it could cover 49 times the area reachable with a conventional cruise weapon when carried from a single shooter," he said.

The maximum flight duration for this hypersonic weapon would be about 10 minutes.

But getting to this point in scramjet development hasn't been easy.

Fulfilling a vision

Propulsion experts today are just now demonstrating a nearly half-century-old vision of expanding the conventional jet engine operating range above Mach 5, Mercier said.

Scientists realized during early experiments that evolving the well-known ramjet to a supersonic combustion engine was a very challenging and complex task.

Al Boudreau, HyTech's program manager, has been working with hypersonics since the early 1960s. "It was pretty crude back then," he said, "and the focus was on doing basic research to prove we could, in fact, light hydrogen in supersonic flight to produce thrust."

Not only have they proven it works with conventional jet fuel, the HyTech team feels they're chipping away at one of the last real frontiers of aeronautics, according to Mercier.

HyTech scientists used a building block approach to solve progressively more complex challenges using the knowledge garnered from preceding tests.

One of the biggest challenges for successful and sustained running of the scramjet was creating a mechanism to ignite the fuel, something similar to a pilot light on your gas stove, Mercier said.

Overcoming challenges

"I'd liken the conditions as trying to light a match in a hurricane. The total time we have to inject the fuel, get the fuel vaporized, initiate combustion and complete combustion before a mass of air enters the combustor and goes through the nozzle is less than one millisecond — that's not much time."

Despite the challenges, Mercier believes the payoffs are tremendous.

In addition to getting good engine performance and operability, the HyTech program is also aiming to build a durable engine that will provide affordable, reusable on-demand space access systems.

"Hytech is not just developing the engine body, but all the accessories that go with it," Boudreau explained. "We're talking about pumps and valves that can handle this very hot, reactive fuel — that's never been done before. It's a total engine package."

Looking to the future

Near-term research and testing emphasis is on "expendables" like cruise missiles, "but the technologies we're developing today could be applied to higher Mach reusable systems like long range strike and reconnaissance aircraft," Mercier explained.

Future hypersonic long-range strike aircraft could reach any spot in the world within three hours and two-stage-to-orbit vehicles would give the Air Force affordable access to space. **@**